TIMET
Henderson, NV

CONSTRUCTION QUALITY ASSURANCE MANUAL

TIMET HENDERSON FACILITY

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1.0 Introduction

1.1 Project Description

This Construction Quality Assurance (CQA) Plan was prepared specifically for the landfill, ponds and remediation-related projects located at the TIMET facility in Henderson, Nevada.

The following liner configuration is typical of the ponds: (in ascending order):

1. Structural fill for construction of perimeter berms
2. 60 mil HDPE Secondary Geomembrane
3. 200 mil Geonet
4. 60 mil HDPE Primary Geomembrane

Pond construction activities, which are covered in this CQA Plan, consist of:

1. Site preparation activities (installing erosion controls and locating and protecting utilities and other existing structures)
2. Surface water conveyance system installation
3. Sub-grade preparation
4. Geomembrane installation
5. Geotextile cushion installation
6. Geonet installation
7. Leak detection sump and pipe installation 8) conveyance pipe

Landfill construction is anticipated to include excavation of a new cell, placement of base geosynthetics, and final cover construction. The specific layer will be designed in the permit modification package and are anticipated to include many of the components in this site manual.

The Soil Management Plan for the site includes the construction of a geosynthetic clay liner (GCL) as a marker and clean cover soils. This manual address the GCL and the cover soil placement.

Purpose and Scope

This CQA Plan was prepared to provide written construction oversight guidance to confirm that the construction activities and completed project comply with the Technical Specifications, Project Drawings, and applicable permit requirements. The CQA Plan summarizes methods, procedures, and frequency of observation and testing activities to document proper installation.

2.0 Organization, Responsibility, and Authority

2.1 Overview

The principal organizations involved in this project include the regulatory agency, Owner, Engineer, Geosynthetic Manufacturer, Earthwork Contractor, Installer, and CQA Technician. The roles and responsibilities of the principal organizations are discussed in the following subsections. A project directory will be prepared at the completion of bidding.

2.2 Regulatory Agency

The regulatory agency representatives for the ponds will be defined at the start of each construction sequence.

2.3 Owner

The site Owner is Titanium Metals Corporation further referred to as “the Owner” who is responsible for operating the facility and is responsible for submittals to the regulatory agency.

2.4 Engineer of Record

The Engineer of Record further referred to as “Engineer” will be responsible for approving and making any necessary design changes, reviewing and approving/rejecting the Earthwork Contractor's submittals, coordinating surveys and CQA Technician's reports and photographs, providing recommendations of material/workmanship to the Owner, and preparing the Construction Documentation Report and Drawings.

2.5 Geosynthetic Manufacturer

The Geosynthetic Manufacturer is responsible for production of the geosynthetic lining components outlined in this CQA manual. In addition, the Manufacturer is responsible for the condition of the geosynthetic until the material is accepted by the Engineer upon delivery. The Manufacturer will produce a consistent product meeting the technical specifications set forth by the manufacturer. Moreover, The Manufacturer will provide quality control documentation for the products produced as specified in this CQA manual.

2.6 Earthwork Contractor

The Earthwork Contractor is ultimately responsible for construction of the ponds structural berms, preparing final surface of sub-grade and excavations for the ponds and the landfill in strict accordance with the design criteria, Project Drawings, and Technical Specifications and for using the necessary construction procedures and techniques; specifically:

- Excavation to approved grade elevations and slopes
- Installation and maintenance of temporary and permanent erosion control measures
- Structural fill
- Anchor trench excavation, backfill and compaction

- Placement of cover soils over geosynthetics
- Construction of necessary site access roads.

Furthermore, the Earthwork Contractor is responsible for surface water management within the project limits until geosynthetics are placed. The Earthwork Contractor is also responsible for coordinating, supervising, and overseeing subcontractors, as needed, to perform construction-related activities.

2.7 Installer

The Installer will be responsible for the delivery, storage, deployment, quality control, and seaming of the geosynthetic components.

2.8 CQA Technician

The CQA Technician is retained by the Owner. The CQA Technician will perform construction inspection responsibilities to confirm construction compliance with the Technical Specifications and Project Drawings by observation, testing verification, and documentation activities. The CQA Technician is responsible for soil inspection, testing, and geosynthetic installation observation to document that the work meets the requirements of the Technical Specifications and Project Drawings. The CQA Technician will be responsible for confirming construction compliance with the Technical Specifications by performing material testing. The Engineer will supervise the CQA Technician(s) during the project.

3.0 Communications

3.1 Overview

A pre-construction meeting, weekly progress meetings, monthly project review meetings, geomembrane pre-installation meeting, and a final inspection meeting will take place on site, unless otherwise announced. The Earthwork Contractor, Installer, subcontractor (as necessary), CQA Technician, and Engineer will attend these meetings. The regulatory agency representative is invited to attend these meetings, however, attendance is optional. These meetings are discussed in the following subsections.

Minutes for all the project meetings will be documented, maintained, and transmitted by the Engineer (unless otherwise noted) to the principal project participants attending each meeting and to those who will be affected by the decisions.

3.2 Pre-Construction Meeting

A pre-construction meeting will be held prior to commencement of construction activities at the work site. The Earthwork Contractor will contact the Engineer of Record at least five working days prior to the anticipated commencement of construction to schedule the pre-construction meeting. The Earthwork Contractor will submit all required submittals prior to project commencement and prior to scheduling the meeting. The pre-construction meeting will be conducted by the Engineer and will be attended by those personnel listed in Section 3.1, including a representative of the Installer. The purpose of this meeting will be to:

- Exchange the following information: business addresses, phone numbers, fax numbers, email addresses, and pager numbers of the Owner, regulatory agency, Engineer, CQA Technician, Installer, and pertinent personnel for the Earthwork Contractor.
- Resolve any uncertainties following the award of the construction contract.
- Review work scope.
- Conduct a site walkover and inspection.
- Discuss the Earthwork Contractor's overall construction schedule and anticipated work hours.
- Discuss project administration.
- Review status of submittals required to be transmitted.
- Discuss any appropriate design modifications.
- Discuss the Earthwork Contractor's Surface Water and Dust Management Plan.
- Discuss the schedule and procedures of the geomembrane installation.
- Schedule weekly progress meetings.
- Discuss Owner's emergency notification and operating practices for emergency situations.
- Review project methods, site security, and safety.
- Determine a regular day of the week and time of day for weekly progress meetings.

3.3 Weekly Progress Meetings

A progress meeting may be held weekly or as desired by Owner. The day of the week and time of day will be determined and agreed upon by all parties at the pre-construction meeting. Changes to the regularly scheduled meeting time will be announced during the previous week's meeting. The meeting will be conducted by the Earthwork Contractor. The purpose of the meetings will be to:

- Review coordination of work.
- Review schedule to expedite the work.
- Review the previous week's activities and accomplishments.
- Review the work location and activities for the week.
- Review the status of the Earthwork Contractor's submittals.
- Review the Earthwork Contractor's progress report for the prior week.
- Identify the Earthwork Contractor's personnel and equipment assignments for the week.
- Discuss any existing or potential construction problems and their respective corrective actions.

3.4 Special Meetings

Special meetings may be called at the discretion of the Owner or the Engineer to resolve problems or other project-related issues.

3.5 Geosynthetics Pre-Installation Meeting

A meeting will be held to discuss the details of the proposed design and installation of the geosynthetics. The Earthwork Contractor will contact the Engineer to schedule the meeting a minimum of one working day in advance of the start of the geosynthetics installation. The Earthwork Contractor, Installer (including the project foreman), Owner, Engineer, and CQA Technician will attend the meeting.

3.6 Final Inspection Meeting

Upon completion of construction activities, a final inspection meeting may be conducted by the Engineer and attended by the Installer and the Earthwork Contractor. The meeting will be scheduled when:

1. The Earthwork Contractor has submitted written certification to the Engineer and the Owner that the Contract Documents have been reviewed
2. The work has been inspected
3. The work is substantially complete in accordance with Contract Documents
4. The work is ready for the Engineer's inspection. The final inspection may consist of a walkthrough inspection of the project site to determine whether the project is complete and consistent with the Contract Documents. Any outstanding construction items discovered during the inspection will be identified and noted on a punch list for the Earthwork Contractor to complete.

4.0 Geosynthetic Manufacturer

All Geosynthetic materials including the geomembrane, geonet and geotextile will be manufactured by GSE Environmental or equal. No substitutes will be used unless requested and approved in writing from the Owner and Engineer.

- Each geomembrane, geonet and geotextile roll will be marked by the manufacturer with the following information (on a durable gummed label or equivalent):
  - Name of manufacturer.
  - Product type and identification number (if any).
  - Panel length and width.
  - Nominal product thickness.
  - Identification number.

4.1 Geomembrane

See Appendix A for Material Specification Sheet

4.2 Geonet

See Appendix A for Material Specification Sheet

4.3 Geotextile

See Appendix A for Material Specification Sheet

4.4 Geosynthetic Clay Liner

See Appendix A for material Specification Sheet.

5.0 Construction Submittals, Inspection, and Testing

5.1 Overview

This Section outlines the work inspections, confirmations, audits, and evaluations of material and workmanship necessary to determine and document the construction quality for the major construction activities listed below:

- Submittals prior to project commencement
- Site preparation and erosion control installation
- Sub-grade preparation
- Structural fill placement and compaction
- Geosynthetic installation
- Geosynthetic testing
- Cover Material Placement
- Project closeout

The CQA activities will provide assurance that the construction was performed as specified in the Project Drawings and Technical Specifications.

5.2 Earthwork

5.2.1 Construction Submittals

The Earthwork Contractor will perform the following activities prior to project commencement, unless otherwise requested in writing by the Earthwork Contractor and approved in writing by the Engineer:

- Report any discrepancies between the existing conditions, project drawings, and actual site conditions to the Engineer and Owner.
- Submit the site superintendent/foreman names and phone numbers to the Engineer and Owner.
- Submit an overall construction schedule to the Owner and Engineer within five working days of the date of the contract award.
- Submit a project-specific Health and Safety Plan to the Engineer and Owner.
- Submit the construction commencement date to the Owner and Engineer five working days prior to project commencement.
- Submit a Surface Water and Dust Management Plan to the Engineer and Owner.
- Submit the imported soil source names and addresses to the Engineer and Owner.
- Submit the cushion geotextile manufacturers' and Installers' names, addresses and experience lists to the Engineer and Owner.
- Submit the pipe product data to the Engineer and Owner.

- Communicate with the Engineer, CQA Technician, and/or Owner regarding any pertinent issues.

5.2.2 Site Preparation and Erosion Control

The Earthwork Contractor will perform the following activities in accordance with Technical Specifications and Project Drawings:

- Submit Material Safety Data Sheets (MSDS) for chemical products to be used on site to the Engineer and Owner prior to those bringing chemicals on site
- Review locations of existing site utilities prior to beginning work
- Review and verify that all survey benchmarks and control makers are acceptable
- Construct and maintain erosion control measures
- Locate and protect all utilities, monitoring wells, leachate collection system, , and other structures
- Communicate with the Engineer, CQA Technician, and/or Owner regarding any pertinent issues

5.2.3 Sub-grade Preparation

The Earthwork Contractor will be responsible for preparing the sub-grade soil for structural fill for berm construction. Specifically, the following activities will be performed in accordance with Technical Specifications and Project Drawings:

- Excavate, grade, and compact the sub-grade as stated in the Geotechnical Report and Project Drawings.
- Perform Dust Control and Surface Water Control Measures to satisfaction of Engineer and/or Owner.
- Notify the Engineer and Owner in writing 48 hours prior to sub-grade completion.
- Communicate with the Engineer, Owner, and/or CQA Technician regarding any pertinent issues.

The Engineer will perform the following activities:

- Monitor construction progress.
- Review, approve/reject, and log project submittals.
- Review the CQA Technician daily logs and photographs.
- Survey the sub-grade surface, as specified in Technical Specifications.
- Notify the Earthwork Contractor and Owner of areas to be adjusted or approved grades.
- Communicate with the Owner, CQA Technician, and/or Earthwork Contractor regarding any pertinent issues.

5.3 Geosynthetic Installation

5.3.1 Pre-Installation Notifications and Submittals

Installation Contractor will provide the following notifications and submittals to the Engineer and Owner prior to starting any geosynthetic installation.

Notifications

- Notify Engineer and Owner in writing of any discrepancies between the existing conditions, project drawings, and actual site conditions.

Submittals Concerning Material Manufacturer

- Submit the resin quality control tests for resin used in manufacturing geomembrane and geonet materials.
- Submit the reclaimed polymer statement.
- Submit the production information for the geomembrane, geonet, GCL, and geotextile.
- Submit the geomembrane, geonet GCL,and geotextile quality control certificate for each roll and quality control test results to the Engineer prior to delivery of the first geosynthetic shipment.
- Submit certificate that extrudate to be used is comprised of same resin as geomembrane to be used.

Submittals Concerning Installer Qualifications

- Submit a project-specific Health and Safety Plan.
- Submit the (geomembrane, geonet, GCL, and geotextile) Installers' names and experience lists.
- Submit the site superintendent/foreman name(s) and phone numbers.

Submittals Concerning Site Construction and Material Installation

- Submit the installation panel layout diagram for the geomembrane.
- Submit documentation for the seaming apparatus to be used on site for the geomembrane.
- Submit pipe boot data.
- Submit the construction commencement date five working days prior to project commencement.
- Submit an overall construction schedule within five working days of the date of the contract award.
- Submit list of seaming devices with identification numbers.
- Submit calibration sheet of shear and peel testing (tensiometer) equipment.

5.3.2 Pre- Installation Submittal Reviews and Acceptance

Installation Contractor will not proceed with any phase of the installation until all pre-construction submittals have been reviewed and accepted by the Engineer and Owner. Installation contractor will correct and re-submit any rejected submittals within 24 hours of rejection notification.

5.3.3 During Installation Notifications, Submittals & Testing

Installation Contractor will perform and provide notifications, submittals and testing results for the following list to the QCA Technician, Engineer and Owner after material delivery and during the installation of the Geosynthetic.

Identification, Sampling, Storage and Transportation

- Assist in obtaining roll tags for each roll prior to usage.
- Obtain samples of the geomembrane, geonet, GCL, and geotextile upon delivery if required for QA testing.
- Inspect the Geomembrane, geonet, GCL, and geotextile rolls once they have arrived at the jobsite. In the event the rolls are damaged, the Installer will provide the CQA Technician with a complete assessment of the extent of damage, and suggested repair methods approved by the manufacturer within 24 hours of time of the inspection and prior to installation. Damaged material will be replaced as directed by the Engineer/Owner.
- Unloading or transfer of the geomembrane, geonet, GCL, and geotextile rolls from one location to another will be done using procedures and equipment that prevent damage to the rolls.
- The geosynthetic material rolls will be stored to ensure that they are adequately protected from the following:
    - Equipment
    - Strong oxidizing chemicals, acids, or bases
    - Flames, including welding spark
    - Ambient temperatures in excess of 160°F
    - Dust and mud
    - Inclement weather
- Whenever possible, a 6 inch minimum airspace will be provided between the rolls and will not be stacked.
- Prior to installation, inspect the surface of each roll for defects and damage, along with the Engineer.

Installation

- Submit Installer daily logs every Monday morning by 9:00am basis during all material placements to the Owner.
- Submit copies of signed Sub-Grade Acceptance Certificates on a daily basis when geosynthetic is deployed.
- Notify CQA Technician when changes in supporting soil conditions occur that may require repair work after the supporting soil is accepted by the Installer.

- Take the following precautions while installing the geomembrane:
    - Equipment used does not damage the geomembrane by handling, excessive heat, high winds, leakage of hydrocarbons, or by any other means
    - Personnel working on the geomembrane will not smoke, wear damaging shoes, clothing, or engage in other activities that could damage the geomembrane
    - The method used to deploy the geomembrane does not cause scratches, scuffs, or crimps in the geomembrane and does not damage the sub-grade.
    - The method used to place the panels minimizes wrinkles.
    - Provide adequate temporary loading or anchoring (continuously placed, if necessary), which will not damage the geomembrane and will be placed to prevent uplift by wind.
    - Direct contact by equipment or tools with the geomembrane will be minimized. The geomembrane will be protected by geotextiles, extra geomembrane rub sheets, or other suitable materials in areas where excessive traffic may be expected. No contact with the geomembrane by heavy construction equipment or motor vehicles with tire pressures exceeding 5 pounds per square inch (psi) will be allowed.
- Designate each roll or blanket with a panel number that is consistent with layout plan and as negotiated in the pre-construction meeting.

<u>Seam Testing</u>

- Test geomembrane seams under the observation of the CQA Technician in accordance with Technical Specifications.
- Maintain and use equipment and personnel at the site to perform testing of test seams. Test seams will be made each day in accordance with Technical Specifications prior to commencing field seaming.
- Test production seams continuously in accordance with Technical Specifications using non-destructive techniques under the observation of the CQA Technician.
- Perform the following destructive seam tests on an average of every 500 linear feet of production seam (locations of the tests will be selected by the CQA Technician, and sufficient samples will be obtained to provide one sample to the Owner, one sample to the CQA Technician for laboratory testing, and one sample to be retained by the Installer for field testing). A bounding sample on each side of the laboratory sample will be tested in the field for three peel and three shear specimens each.
    - Peel Tests Specimens:
        - Fusion Seams - The inside and outside tracks of specimen will meet the minimum requirements outlined in Appendix A for ultimate strength and Film Tearing Bond (FTB).
        - Extrusion Seams - Specimens will meet minimum requirements outlined in Appendix A for ultimate strength and FTB
    - Shear Tests Specimens:
        - Fusion Seams - specimens must achieve the minimum required in Appendix A and have an FTB

    - Extrusion Seams - specimens must achieve the minimum required in Appendix A and have an FTB

- Perform field destructive tests on the end of the seam for 100 foot or longer seams, one peel, and one shear as defined in Table 2 of Appendix A.
- Repair damaged and sample coupon area in the geomembrane.

Panel Leak Testing

- After deployment and seaming, Installer shall perform leak testing of geomembrane in accordance with ASTM D-7240
- Installer shall demonstrate equipment to show working order and identification of a defect. Documentation of wipe speed and distance equipment can be off of the geomembrane will be documented
- Installer well perform leak test and demonstrate maximum coverage of geomembrane
- Defects will be labeled and reported
- Installer shall submit documentation statement of tested area on a daily basis
- Traffic on tested areas shall be minimized after approvals

Submittals

- After installation, submit the following to the Engineer and CQA Technician:
    - Construction Drawing (include details and locations of the connection to the existing geomembrane liner, anchor trench, panel layout, and repairs).
    - Copy of materials and installation warranty, covering both for a period of two years from date of substantial completion.
- Communicate with the Engineer, Owner, and/or CQA Technician regarding any pertinent issues

6.0 Owner Responsibilities

6.1 Overview

The Owner will perform the following activities:

- Provide access to project site.
- Monitor submittals and submittal review process.
- Inform Contractor, Installer, Engineer, and CQA Technician of site specific health and safety requirements.
- Communicate with Earthwork Contractor, CQA Technician, and/or Engineer regarding any pertinent issues.

7.0 Engineer Responsibilities

7.1 Overview

Review and Approve/Reject

- All CQA Technician's daily logs, photographs and submittals
- All Installer submittals.
- All Earthwork Contractor submittals
- All soil and geomembrane testing data.

Performed Activities

- Notify the Owner in writing of the identities and qualifications of all the contractors involved in the geosynthetic construction. The following minimum information will be included, if available, for pre-construction report:
    - Identification of polymers and admixtures, quality control for the raw material, fabrication methods, quality control of the geomembrane panels delivered to the site, sources of resin, panel fabricators, and specific factory seaming method with detailed description of the process will also be identified.
    - Quality control for transporting and storing the geomembrane rolls.
    - An experience record of the Installer to show projects completed within the last five years, including: name, address, phone number of contact, type of application, and acreage completed.
    - The proposed equipment to be used in geomembrane installation, including: machinery used in panel deployment, soil cover placement, and geomembrane seaming and testing. Operating temperature and speed of seaming will also be identified.
    - Quality control for factory and field seams, including: identification of the destructive and nondestructive testing equipment with standards which define field seam failure and frequency of calibration of the testing equipment.
- Notify the Owner prior to geomembrane installation of the time and date of the start of geomembrane installation.
- Prior to commencing installation, Engineer will submit Installer’s panel layout to Owner. The layout plan will include the following:
    - Size and configuration of all panels to be assembled in the field with a panel identification scheme.
    - General location and type of all factory and field seams.
    - Construction detail for all geomembrane-related work, including but not limited to:
        - Minimum panel overlap.
        - Temporary panel anchoring methods.
        - Plan for covering geomembrane with traffic routing shown.

- Monitor all construction progress
- Accept the geomembrane liner when:
    - Written certification letter, including record drawings, are received by the Owner and Engineer.
    - Installation is complete.
    - Documentation of installation is completed, including the CQA Technician's final report.
    - Verification of adequacy of field seams and repairs, including associated testing, is complete.
- Communicate with the Owner, CQA Technician, and/or Installer regarding any pertinent issues.
- Notify the Installer and CQA Technician of areas to be adjusted or approved areas.

8.0 CQA Technician Duties

8.1 Overview

The CQA Technician will perform the following communication, observations and documenting activities pertaining to each phase of construction:

8.1.1 General Communication

Verbal

- Verbally communicate with the Owner, Engineer, and/or Installer regarding any pertinent issues
- Verbally communicate the results for each field seam sample to the Engineer within one working day after the samples have been tested. Any uncertainty of the results will be addressed at that time by the Engineer. The Engineer will determine final acceptability of the seam
- Inform the Installer and Engineer when the weather conditions are questionable and may not be in conformance with the Technical Specifications. The Engineer will determine if the weather conditions are acceptable

Written

- Submit daily reports and photographs to Engineer by 7:00 am for the previous day
- Provide Earthwork Contractor written certification of completion to geomembrane installation
- Provide hard copy of destructive seam test results to owner and installer

8.1.2 Observations and Documentation

8.1.2.1 Earthwork

- Perform the following as required in the Technical Specification and Project Drawings:
  - Dry density and as-placed moisture content will be determined on an approximate 100 foot grid pattern for each 1 foot thickness of fill placed. The grid pattern will be offset on each subsequent layer of tests. Additionally, a minimum of two (2) density and moisture content tests for each 1 foot thickness of structural fill placed will be performed to fully define the degree of soil compaction obtained in confined areas where equipment movement is hindered or hand compaction is necessary.
  - One moisture-density curve will be developed for every 5,000 cubic yards (cyd) or less of structural fill placed and for each major soil type utilized. At least five points will be established for each curve. A representative sample for every 5,000 cyd or less of fill will be analyzed for grain size distribution and for Atterberg limits. If apparent changes in soil quality are observed during fill placement, a one-point Proctor analysis will be utilized to verify the applicability of previously analyzed moisture-density curves.
- Density and moisture content test during each 12” lift of structural fill per Table 1.
- Collect structural fill samples at the frequency required in the Technical Specifications.

- Observe and document the condition of the final lift of structural fill prior to geomembrane installation. Document presence of coarse gravel or cobbles present at surface of fill after rolling that may damage geomembrane.
- Perform the following for anchor trenches:
    - Prior to installation of the geosynthetics in the anchor trench, document that the trench is free of standing water and that the trench has been constructed according to the Technical Specifications and the Project Drawings.
    - Observe the backfilling of the anchor trenches for conformance with Technical Specifications. Any discrepancies will be reported to the Installer and/or Earthwork Contractor for correction.
- Monitor construction progress
- Log Earthwork Contractor submittals
- Review and approve/reject the Earthwork Contractor submittals.
- Communicate with Owner, Engineer, and/or Earthwork Contractor regarding any pertinent issues

8.1.2.2 Pre-Installation of Geosynthetic

- Document on-site storage areas conditions prior to material arrival
- Prior to deployment, inspect the surface of each roll for defects and damage, along with the Installer (defected or damaged rolls or portions of rolls, as well as those without identification labeling, will be rejected and removed from the site and replaced with new rolls)
- Obtain samples from the Installer upon delivery of the geosynthetics to the site at the frequency stated in the Technical Specifications
- Observe and document that the handling equipment used on the site is industry standard and conforms to the geosynthetic manufacturer's recommendations and intent
- Obtain the roll tags from the Installer
- Check delivered material for proper labeling with the Installer
- Observe and document on-site storage of the geosynthetics is as specified in Technical Specifications

8.1.2.3 Geomembrane Installation

8.1.2.3.1 Obtain and Document the following

- Weather conditions during installation
- All project submittals
- Production seam samples from the Installer for archiving (assign a number to the archive sample and mark the sample with the number. Also, log the date, seam number, approximate location in the seam, and field test pass-or-fail description, if applicable).
- All production seam field test procedures conducted by the Installer.
- The successful test seam samples from the Installer for archiving.

- Test seam samples from the Installer for the laboratory destructive testing.

8.1.2.3.2 Observe and Document the following

- General Placement and Installation
    - The method used to unroll the panels and observations of scratches or crimps in the Geosynthetic materials, and damage to the underlying soil layer resulting from the unrolling method.
    - The Geosynthetic rolls which have repairable minor flaws according to the Technical Specifications.
    - Any miss-handling or storage of the Geosynthetic materials
    - Equipment used on and for the installation of the Geosynthetic materials
    - The method used to place the panels to minimize wrinkles.
    - The actions taken to protect the geomembranes during installation
    - The identification code, location, and date of installation of each panel and record on a field drawing
    - For damage panels after placement and before seaming is initiated and inform the Installer which panels or portions of panels, will be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Technician. Repairs will be made by the Installer according to Technical Specifications.
- Seaming (Trial Testing)
    - The Installer while performing trial test seams and assign a number and mark the test seam samples (in addition, log the date, hour, ambient temperature, number of seaming unit, name of operator, and pass-or-fail description).
    - Perform the following during non-destructive seam continuity testing:
        - Any discrepancies with the Project Specification will be reported to the Engineer and the Installer.
        - Record the seam number, date of observation, name of tester, and outcome of the test or observation.
        - Document locations where the seam cannot be non-destructively tested after final placement, and visually inspect the seam.
        - Inform the Installer of any required repairs. The Installer will complete any required repairs in accordance with the Technical Specifications.
        - If repair work is performed, observe the repair and the testing of the repair. In addition, mark on the geomembrane that the repair has been made, and document the results.
    - Select the locations for destructive seam testing to be performed by the Installer (the tests will be performed on an average of no greater than 500 linear feet). Follow the procedures listed and outlined in Technical Specifications for destructive test failure.

- Seaming (Production)
  - The seam area for cleanliness and absence of moisture, dust, dirt, debris of any kind, and foreign material.
  - Conformance of seam overlap with Technical Specifications.
  - Seams are aligned to prevent wrinkles and "fish-mouths."
  - The seaming techniques for the prevailing weather conditions are being employed in conformance with Technical Specifications. If adverse weather conditions do occur, the CQA Technician will notify the Installer as to whether or not to seam for the day.
  - Equipment.
    - The Installer maintains on site at least two each of the following operable spare apparatus: extrusion welder, fusion welder, and generator.
    - The extruder is purged prior to beginning a seam or repair until the heat-degraded extradite has been removed from the barrel.
    - The geomembrane is protected from damage in heavy traffic areas.
    - The Installer's calibration records for welding apparatus temperature gauges.
    - Apparatus temperature and ambient temperature at appropriate intervals.
  - The CQA Technician may perform additional testing to verify that the geomembrane seams meet the Technical Specifications.

Verify and Document

- All rejected rolls of material, or portions thereof, have been removed from the site.
- The panel locations are placed according to the Installer's shop drawings, as approved or modified at the pre-construction meeting. Any discrepancies in panel locations will be documented and reported to the Owner.
- The fill surface each day of the geomembrane installation to evaluate desiccation cracking and report desiccation to the Earthwork Contractor for repair.
- The geomembrane seam strength requirements are achieved as listed in Tables 2 in Appendix A.
- The geomembrane thickness is in conformance with Technical Specifications. Five thickness readings will be taken for every roll. Readings will be taken across the width at any point where the panel has been cut. Any non-conformance will be reported to the Installer for correction
- Ship final destructive seam samples to laboratory for testing and report results

8.1.2.4 Geosynthetic Clay Liner Installation

8.1.2.4.1 Obtain and Document the following

- Weather conditions during installation
- All project submittals

- Subgrade soil surface acceptance forms

8.1.2.4.2 Observe and Document the following

- General Placement and Installation
    - The method used to unroll the panels and observations of scratches or crimps in the Geosynthetic materials, and damage to the underlying soil layer resulting from the unrolling method.
    - The Geosynthetic rolls which have repairable minor flaws according to the Technical Specifications.
    - Any miss-handling or storage of the Geosynthetic materials
    - Equipment used on and for the installation of the Geosynthetic materials
    - The method used to place the panels to minimize wrinkles.
    - The actions taken to protect the geomembranes during installation
    - For damage panels after placement inform the installer which panels or portions of panels, will be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Technician. Repairs will be made by the Installer according to Technical Specifications.
- Seaming
    - The Installer or contractor shall provide powdered bentonite for overlaps.

9.0 Documentation

9.1 Overview

Documentation for this project will per performed by the QCA Technician with the required assistance and information provided by the Grading Contractor and Geosynthetic Installation Contractor. Documentation will include daily field reports, photo logs, and final construction documentation. These elements are discussed in the following subsections.

9.2 Daily Field Reports

All observations, relevant discussions with on-site personnel, measurements, and meetings will be documented in the Daily Field Reports and Supplements by the CQA Technician. At a minimum, the following will be recorded each construction day (see attached forms in Appendix B):

General Information

- Date, project name, location, and other identification.
- Weather conditions.
- Significant changes in the weather, as well as when the change occurred.
- When and where work was performed.
- What equipment, methods, and materials were used to perform the work.
- Estimated quantities of materials used or delivered to the site.
- Reports on any meetings held and their result (Engineer to complete meeting minutes).
- Modifications/deviations from the approved Technical Specifications and this CQA Plan.
- Site visits by the Owner or Engineer.
- Name of person making the observations or measurements or documenting the meeting and their signature.
- In addition, the CQA Technician will document the date and duration each person performs CQA activities. This includes the Engineer and CQA Technician as well as the Owner.
- Observe and document (daily logs and photographs) the placement and testing of the geomembrane. At a minimum, the following information will be documented:
- Amount and location of geosynthetics placed. Changes from the fabrication plan will be noted.
- Identification of the panel numbers for the geomembrane panels installed.
- Location of field seams, patches, and repairs.
- Result of geomembrane test seams.
- Results of geomembrane nondestructive seam repair testing.
- Location of and reason for repairs made and results of the non-destructive testing of those repairs.

- Location of samples taken for destructive testing.
- Calibrations or recalibrations of test equipment action taken as a result of recalibration.

9.3 Photographic Log

Photographic reporting will be used to document construction progress, construction activities, construction problems, and remedial actions. Photographs will be taken by CQA Technician. These photographs will serve as a pictorial record of work progress, problems, and corrective measures.

At a minimum, photographs will be taken before, during, and after the following major construction phases:

- Date, time, place, and unique identification of photographs
- Site preparation and erosion control installation
- Sub-grade preparation including Structural fill placement and compaction
- Cushion geotextile installation
- 60 mil HDPE Secondary Geomembrane installation
- Granular drainage layer placement at leak detection sump
- Geonet installation
- 60 mil HDPE Secondary Geomembrane installation
- GCL installation
- Seaming procedures and equipment
- At least 10 photos during any testing (grading and Geosynthetic installation)
- Unforeseen problems and resulting activities
- At a minimum, photographs will be taken to document any accidents, unusual conditions, material testing, location of stockpiled materials, and post-construction site and vicinity conditions

All photographs will be logged in a field book. Digital photographs will be copied to CDs for backup storage archive. A unique identification number of the photo and photo log in which the photo was recorded in.

- Name of photographer.
- Date and time the photo was taken.
- Where the photo was taken from.
- The photo significance.

The photographs and photo logs will be kept in a protective file (i.e. photo album or digital file) in chronological order. The file will contain color prints. Photographic records will be updated weekly for review by Engineer.

9.4 Construction Documentation Report

Upon completion of the Project, the Engineer will submit to the Owner a Construction Documentation Report.

The report will document all aspects of construction and will be prepared for:

- The initial site preparation
- The Sub-grade construction activities including final grade elevations and test results
- The installation of all geosynthetic materials and test results
- The report will include a Certification Statement
- Project submittals, submittal review and approved documents
- Photographic Log
- Communicate with Earthwork Contractor, Installer, Owner, and/or CQA Technician regarding any pertinent issues
- Final as built construction drawings

Appendix A
Tables

Table 1 - Fill Testing Summary

Test	Test Method	Sample/Test Frequency	Acceptance Criteria
Nuclear Density(1)(2)	ASTM D 6938	1 per 100 foot-grid* (minimum 5 per acre per 1 foot thickness of fill)	Min. 90% of Modified Proctor
Moisture Content(1)(2)	ASTM D 6938	1 per 100 foot grid* (minimum 5 per acre per 1 foot thickness of fill)	Wet of optimum when possible to reduce dust

NOTES: * Location as selected by CQA Technician.

(1) Dry density and as-placed moisture content will be determined on an approximate 100 foot grid pattern for each 1 foot thickness of fill placed. The grid pattern will be offset on each subsequent layer of tests. Additionally, a minimum of two density and moisture content tests will be performed for each 1 foot thickness of fill placed in confined areas where equipment movement is hindered or hand compaction is necessary.

(2) Locations will be determined in the field

Table 2 – 60 mil HDPE Production Seam Requirements

Type of Seam	Peel Requirements GRI-GM 19	Shear Requirements GRI-GM 19
Fusion	Four out of five specimens must achieve: 1. 91 ppi minimum tensile strength at yield for fusion welds of 60 mil sheet, 2. FTB with no greater separation than 25% of the width of the track, and 3. The fifth specimen must achieve 80% of the above passing strength requirement or 73 ppi.	Four out of five specimens must achieve: 1. 120 ppi minimum tensile strength at yield, and 2. FTB with 25% or less incursion as a percentage of the track. 3. The fifth specimen must achieve 80% of the above passing strength requirement or 96 ppi.
Extrusion	Four out of five specimens must achieve: 1. 78 ppi minimum tensile strength at yield for extrusion welds of 60 mil sheet, 2. FTB with 25% or less incursion as a percentage of total weld area, and 3. The fifth specimen must achieve 80% of the above passing strength requirement or 62 ppi.	Four out of five specimens must achieve: 1. 120 ppi minimum tensile strength at yield, and 2. FTB with 25% or less incursion as a percentage of the weld area. 3. The fifth specimen must achieve 80% of the above passing strength requirement or 96 ppi.

NOTE:
FTB = Film Tearing Bond: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation of the bonded area. (As defined in NSF Standard 54-1993).

Table 3 – 60 mil HDPE Smooth & Textured Leak Location Geomembrane Properties

Test Properties	Test Method	Testing Frequency (minimum)	60 mil Test Values	
			Textured	Smooth
Thickness (min. ave.)	D 5199	Per roll	Nom. (-5%)	60 mil
• Lowest individual for 8 out of 10 values	or		-10%	--
• Lowest individual for any of the 10 values	D 5994		-15%	-10%
Asperity Height (min. ave.) (1)	D 7466	every 2nd roll (2)	18 mil	--
Density (min. ave)	D 1505	200,000 lb	0.940 g/cc	0.940 g/cc
Tensile Properties (min. ave.) (3)	D 6693	200,000 lb		
• Yield strength	Type IV		126 lb/in.	126 lb/in.
• Break strength			90 lb/in.	228 lb/in.
• Yield elongation			12%	12%
• Break elongation			100%	700%
Tear Resistance (min. ave)	D 1004	45,000 lb	42 lb	42 lb
Puncture Resistance (min. ave.)	D 4833	45,000 lb	90 lb	108 lb
Stress Crack Resistance (4)	D 5397	Per GRI-GM 10	300 hr.	300 hr.
Carbon Black Content (range)	D 1603 (5)	20,000 lb	2.0-3.0%	2.0-3.0%
Carbon Black Dispersion	D 5596	45,000 lb	Note (6)	Note (6)
Oxidative Induction Time (OIT) (min. ave.) (7)		20,000 lb		
(a) Standard OIT	D 3895		100 min.	100 min.
(b) High Pressure OIT	D 5885		400 min	400 min
Oven Aging at 85°C (7), (8)	D 5721	per formulation		
(a) Standard OIT (min. ave.) retained after 90 days	D 3895		55%	55%
(b) High Pressure OIT (min. ave.) retained after 90 days	D5885		80%	80%
UV Resistance (9)	GM 11	per formulation		
(a) Standard OIT (min. ave.)	D 3895		N.R. (10)	N.R. (10)
(b) High Pressure OIT (min. ave) retained after 1,600 hrs (11)	D5885		50%	50%

Notes:

1. Of 10 readings; 8 out of 10 must be ≥ 13 mils, and lowest individual reading must be ≥ 10 mils; also see Note 6.
2. Alternate the measurement side for double sided textured sheet.
3. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
   - Yield elongation is calculated using a gage length of 1.3 inches
   - Break elongation is calculated using a gage length of 2.0 inches
4. P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
5. Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.
6. Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.
7. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
8. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response
9. The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
10. Not recommended since the high temperature of the std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
11. UV resistance is based on percent retained regardless of the original HP-OIT value.

Table 4 – Geonet Properties

Test Properties	Test Method	Testing Frequency (minimum)	Minimum Average Roll Values (200 mil)
Thickness, mil (3)	ASTM D 5199	1/50,000 ft^2	200
Transmissivity (2) , (gal/min/ft)	ASTM D 4716	1/540,000 ft^2	9.6
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94
Tensile Strength (MD), lb/in	ASTM D 7179	1/50,000 ft^2	45
Carbon Black Content, %	ASTM D 4118	1/50,000 ft^2	2.0

Notes:
1. Geonet thickness is nominal value
2. Gradient of 0.1 normal load of 10,000 psf, water at 70° F, between steel plates for 15 minutes.
3. Roll widths and lengths have a tolerance of ±1%

Table 5 – Cushion Geotextile Properties

Test Properties (1)	Test Method	Testing Frequency (minimum)	Minimum Average Roll Values (12 oz)
AASHTO M288 Class	N/A	N/A	>>1
Mass Per Unit Area, oz/yd^2	ASTM D 5261	90,000 ft^2	12
Grab Tensile Strength, lb	ASTM D 4632	90,000 ft^2	320
Grab Elongation, %	ASTM D 4632	90,000 ft^2	50
GBR Puncture Strength, lb	ASTM D 6241	90,000 ft^2	925
Trapezoidal Tear Strength, lb	ASTM D 4533	90,000 ft^2	125
Apparent Opening Size, Sieve No.	ASTM D 4751	540,000 ft^2	100
Permittivity, sec^{-1}	ASTM D 4491	540,000 ft^2	0.80
Water Flow Rate, gpm / ft^2	ASTM D 4491	540,000 ft^2	60
UV Resistance % retained after 500 hours	ASTM D 4355	Per Formulation	70

Notes:
1. The property values listed are in weaker principal direction. All values listed are minimum average roll values except apparent opening size in (mm) is a maximum average roll value and UV is a typical value.

Table 6 – Geosynthetic Clay Liner Properties

GEOSYNTHETIC CLAY LINER		
Property	**Method**	**Value**
Index Flux	ASTM D 5887	1 x 10^{-8} m^3/m^2-sec.maximum
Mass Per Unit Area		
1. Bentonite Content	ASTM D 5993	0.75 lb/ft^2 dry weight minimum
2. Geotextile Upper Layer (nonwoven)	ASTM D 5261	6.0 oz/yd^2 minimum
3. Geotextile Lower Layer (nonwoven)	ASTM D 5261	6.0 oz/yd^2 minimum
Swell Index	ASTM D 5890	24 ml/2 g minimum
Moisture Content	ASTM D 4643	12% maximum

Appendix B
Field Forms

Sub-Grade Surface Acceptance Log

Geosynthetic Inventory Check List Log

Geomembrane Panel Placement Log

Geomembrane Trial Seam Weld Log

Geomembrane Production Seam Log

Geomembrane Destructive Test Log

Geomembrane Non-Destructive Log – Air Test

Spark Test Log